Shear behaviour of magnetorheological elastomers: viscoelastic and magnetorheological properties

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ABSTRACT

The magnetorheological elastomers (MRE) are a class of smart materials which modifies their mechanical properties due to an external stimulus, the magnetic field. These materials are gaining increasing popularity nowadays, since the possibility to have free shape MREs could lead to the design of smart components or sensors, which exhibits full integration with the structure. Therefore, the proper design of a MRE system first requires the knowledge of the magneto-mechanical properties of the MRE material. This paper presents the experimental characterization of several specimens of MRE with different ratio of ferromagnetic particles curing conditions and applied magnetic field. The MRE elastomer is composed by two main ingredients: a base elastomer and carbonyl iron powder, which are mixed in the desired weight ratio, following a structured experiment plan. The PDMS elastomer, a commercial silicon which showed a good castability in a previous work, is polymerized by mixing the base material with a curing agent and the iron particles at the same time. We decide to characterize the shear behaviour of the bulk MRE in a condition quite close to a typical application such as an isolation mount. This requires the design of a special rig to apply both the load to the cylindrical specimens, showed in Figure 1, and the magnetic field at the same time. This method, compared to the use of a traditional rheometer as already present in technical literature, grants the possibility to test the specimen in large deformation and up to failure. The specimens were manufactured and tested according to a Design of Experiment method, in order to obtain a statistically significant influence of the variables considered (particles volume fraction, isotropicity and applied field. Moreover, the MRE was tested at low shear rate, in order to avoid the viscoelastic effects and in high shear rates, in order to evaluate the dynamic effects. The experimental results are expressed in terms of the real and complex elastic modulus of the material, stress-strain curves and energy dissipated during the tests. The analysis of variance performed on the test results highlights which are the most important variables that affect the output responses and could be used to build a simplified phenomenological model of the MRE shear behaviour.

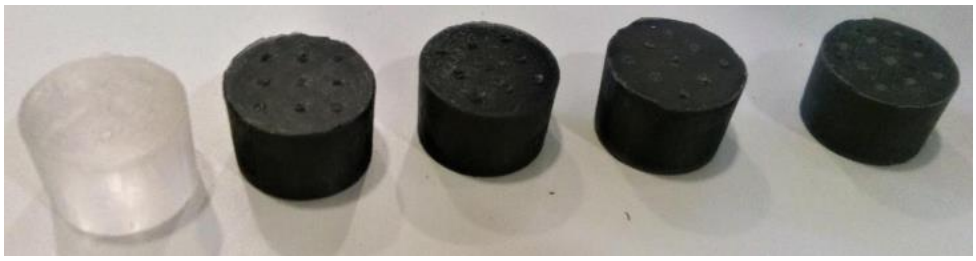

Figure 1 - Specimens of MRE considered in the shear tests

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